Columbia River Project Water Use Plan
Monitoring Program Terms of Reference

ARROW LAKES RESERVOIR OPERATIONS MANAGEMENT PLAN

- CLBMON-36 Kinbasket and Arrow Lakes Reservoir: Nest Mortality of Migratory Birds due to Reservoir Operations

25 January 2008
TERMS OF REFERENCE FOR THE COLUMBIA RIVER
PROJECT WATER USE PLAN

ARROW LAKES RESERVOIR OPERATIONS
MANAGEMENT PLAN

1.0 OVERVIEW

This document presents Terms of Reference for wildlife monitoring studies being delivered under the Arrow Lakes Reservoir Operations Management Plan. These programs will monitor wildlife populations and their habitats in response to reservoir operations, revegetation programs in Kinbasket and Arrow Lakes Reservoirs, and wildlife physical works projects in Arrow. To the extent possible, these programs will also aim to address concerns related to the potential effects of five-unit operations at Revelstoke Dam on wildlife and wildlife habitat.

This document provides detailed Terms of Reference for the following programs:

1) CLBMON 36 Kinbasket and Arrow Lakes Reservoir: Nest Mortality of Migratory Birds due to Reservoir Operations: a 10-year program to determine the extent to which reservoir water levels affect the nesting success of birds breeding in the drawdown zones of the Kinbasket Reservoir and Arrow Lakes Reservoirs, and the significance of nest mortality to bird populations.

2) CLBMON 37 Kinbasket and Arrow Lakes Reservoir: Amphibian and Reptile Life History and Habitat Use Assessment: a 11-year program to monitor the abundance and distribution of amphibians and reptiles within the drawdown zones of Arrow Lakes and Kinbasket reservoirs, determine the impacts of reservoir operations on reptile and amphibian populations, and evaluate the efficacy of physical works and revegetation initiatives to enhance amphibian and reptile populations or their habitats.

3) CLBMON 39 Arrow Lakes Reservoirs Neotropical Migrant Use of the Drawdown Zone: a 10-year program to assess the impact of Arrow Lakes Reservoir operations on the abundance, diversity and distribution of neotropical migrants during fall migration.

4) CLBMON 40 Arrow Lakes Reservoir: Arrow Lakes Reservoir Shorebird and Waterbird Monitoring Program: a 10-year program to determine the abundance, distribution and habitat use of waterbirds and migratory shorebirds and the productivity of waterbirds in Revelstoke Reach, and to examine how variation in flow and reservoir water elevations influence these birds in Revelstoke Reach.
2.0 MANAGEMENT PLAN RATIONALE

2.1 Arrow Lakes Reservoir

Early in the Columbia River water use planning process, a distinction was made between those operating alternatives that required some negotiation with the United States, and those that could be implemented unilaterally by BC Hydro. The former included changes such as the rainbow trout and mountain whitefish flows in the lower Columbia River. The latter category included a wide range of alternatives, focusing primarily on Arrow Lakes Reservoir. It was assumed that BC Hydro had several mechanisms through which it could unilaterally change flows, including the Non-Treaty Storage Agreement (NTSA) with the United States. This was particularly important in achieving a rapid drawdown of Arrow Lakes Reservoir in the late summer and early fall periods to benefit migratory birds and vegetation. All of these alternatives used the NTSA to some extent to achieve this fall drawdown.

With the release provision of the NTSA ending in June 2004 and negotiations with the United States having failed to produce a replacement agreement, the Consultative Committee was presented with a modification to how the Columbia...
River water use planning process must consider operating alternatives for Arrow Lakes Reservoir. The spring and summer constraints on Arrow Lakes Reservoir operations are the only changes that BC Hydro could implement unilaterally once ordered by the Comptroller of Water Rights. Any change in the summer and fall constraints would have to wait until negotiations with the United States are completed and, therefore, would not occur over the short term. Further, without the NTSA in place, all of the alternatives would have significantly higher financial costs and perhaps a different balance between Arrow Lakes and Kinbasket reservoir levels.

While several options for completing the Columbia River Water Use Plan were discussed by the Consultative Committee, consensus agreement was reached around developing soft constraints for Arrow Lakes Reservoir to meet the interests and stated objectives of the Committee (Table 2). It was recognized that there are some areas of common ground among the soft constraints and some potential conflicts that will be removed through implementation of physical works. However, there remain a number of conflicting interests and the degree to which they occur will vary by water year. It was acknowledged that BC Hydro would have to balance these trade-offs internally through choosing its water management strategy. This balance would be informed by the expressed values of the Committee, the performance measures calculated to date, the efficacy of the physical works, and the evolution of knowledge gained through the monitoring program to guide operational decisions.

<table>
<thead>
<tr>
<th>Interest</th>
<th>Constraint</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vegetation</strong></td>
<td>Maintain current level of vegetation in the drawdown zone by maintaining lower reservoir water levels during the growing season. No specific operating targets were identified to meet this general objective.</td>
</tr>
<tr>
<td></td>
<td>If vegetation is showing signs of stress as a result of inundation during the early part of the growing season (May to July), target lower reservoir levels in the fall to allow exposure of plants during the latter part of the growing season.</td>
</tr>
<tr>
<td></td>
<td>Preservation of current levels of vegetation at and above elevation 434 m (1424 ft) is considered a priority.</td>
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<tr>
<td><strong>Wildlife</strong></td>
<td>Ensure that inundation of nesting bird habitat by rising reservoir water levels in early summer is no worse than that which occurred on average over recent history (1984 to 1999). Match operating levels to inundation statistics for elevations 434 m (1424 ft) and above over the 1984 to 1999 period, which were used to produce the average historic performance measure score for spring/summer nesting short-eared owl habitat.</td>
</tr>
<tr>
<td></td>
<td>Ensure that availability of migratory bird habitat in the fall is as good as or better than that which has been provided on average over recent history (1984 to 1999). Draft the reservoir quickly after full pool is reached, targeting a reservoir level of 438 m (1437 ft) or lower by August 7.</td>
</tr>
<tr>
<td><strong>Fish</strong></td>
<td>Ensure appropriate reservoir elevations for tributary access during the kokanee spawning period (late August to early November). Reservoir levels of or below 434 m (1424 ft) could cause tributary access to be restricted in some streams under certain conditions. Proposed monitoring study aimed at determining reservoir level thresholds under a range of tributary streamflow conditions below which spawner access becomes a problem.</td>
</tr>
<tr>
<td><strong>Recreation</strong></td>
<td>Target reservoir water levels between 437 m (1433 ft) and 439 m (1440 ft) from May 24 to September 30.</td>
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<td></td>
<td>Flexibility to achieve lower reservoir levels of 434 m (1424 ft) during the recreation season would be acceptable with proposed construction/upgrade of boat ramps for recreation interests served by these formal access points.</td>
</tr>
<tr>
<td>Interest</td>
<td>Constraint</td>
</tr>
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</tr>
<tr>
<td>Culture and Heritage</td>
<td>Maintain reservoir water levels at or below 436 m (1430 ft) for as long as possible. First Nations are willing to accept water levels above this 20% of the time (or for 2.5 months) provided that it is timed in accordance with the vegetation efforts. First Nations would be willing to relax this constraint if the archaeological site protection plan is underway.</td>
</tr>
<tr>
<td>Erosion</td>
<td>Minimize duration of full pool events. Reservoir water levels of 439 m (1440 ft) are ideal. Avoid sudden drawdown once full pool has been reached (particularly if high runoff has saturated the reservoir banks) to avoid slumping of the shores.</td>
</tr>
<tr>
<td>Power Generation</td>
<td>Optimize power values.</td>
</tr>
</tbody>
</table>

In supporting soft constraints for Arrow Lakes Reservoir, the Consultative Committee acknowledged that long-term data collection will be critical to assessing its impacts on fish, vegetation and wildlife, heritage and recreation interests, and its performance in meeting the objectives for the reservoir. Given considerable uncertainties around the response of vegetation, wildlife and fish resources to operation of the reservoir, a number of assumptions were built into the modeling of constraints and performance measures, which require verification through ongoing monitoring. Specifically, there is a great deal of uncertainty around the relative importance of timing, duration and depth of inundation on the distribution, biomass and diversity of vegetation within the drawdown zone, and around multi-year stresses on vegetation survival. Further, the lack of data on the relative abundance, distribution and seasonal patterns of habitat use by wildlife precluded the consideration of many species groups in the Water Use Plan assessments and limited the predictive capability of modeling impacts on nesting and migrating shorebirds.

2.2 Revelstoke Unit 5

Subsequent to the Columbia River WUP consultative process, BC Hydro undertook further consultation related to the Revelstoke Unit 5 Project. Through this latter process, the WUP monitoring programs and physical works were re-evaluated in the context of incremental changes in operations at Revelstoke Dam. A basic recommendation that resulted from this assessment is that the Columbia WUP projects should be adapted to consider the potential changes in flow and water surface elevation resulting from the Revelstoke Unit 5 Project and the Revelstoke Unit 6 project should that project move ahead during the life of the Columbia WUP. In most cases, specific additions to the design and content of the Columbia WUP monitoring programs can be accommodated within the existing scope of the program. In addition, it was recommended that the Columbia River Water Use Plan wildlife habitat and revegetation physical works programs should be adapted to incorporate the potential effects of 5-unit operations. Specific recommendations related to the wildlife projects included:

- The location of physical works projects must take into account areas inundated under REV5 (and REV6).
- The Terms of Reference for the proposed WUP monitoring programs related to birds and amphibians/reptiles should take into account and include monitoring for the potential effects of REV5.
Specific changes that are required were:

- To ensure that all land and water birds are included.
- Water temperature monitoring in wetlands created by new physical work

Revelstoke Unit 5 will be operational in 2010, allowing for the collection of two years of baseline data.

2.3 Kinbasket Reservoir

An obstacle to making recommendations around operational changes or physical works in lieu of operational changes for Kinbasket Reservoir was the lack of quantitative data wildlife populations. The Consultative Committee acknowledged the importance of better understanding reservoir ecology and the influence of current operations as an outcome of the water use planning process, and supported a plan to collect the information necessary to better inform future decision-making. Two of these studies have been incorporated into this management plan, while two additional studies are presented in the Kinbasket & Arrow Reservoir Vegetation Management Plan; CLBMON-11 Wildlife Effectiveness Monitoring of Revegetation in Kinbasket and Arrow Lakes Reservoir and CLBMON-13 Inventory of Mosquito Populations in the Revelstoke Area.

2.4 Reservoir Hydrology

A primary consideration for all monitoring studies included in the Arrow Lakes Reservoir Operations Management Plan is the impact that reservoir operations (e.g., daily, seasonal and annual water level fluctuations) have on wildlife and wildlife habitat. Figures 1 and 2 provide hydrographs for the Kinbasket and Arrow Lakes reservoirs, respectively. As conditions on these reservoirs can be unpredictable, the monitoring programs maybe altered, interrupted, or curtailed in any given year. Components of these monitoring programs will be scheduled as required to provide the safest and most efficient delivery.
Figure 1  Arrow Lakes Reservoir Hydrograph

Arrow Lakes Reservoir Levels

Study date: June 12/07

Level = 1433.5 ft

Forecast Max Level = 1442 ft

Actual Min Level (Mar 4) = 1402 ft

Level = 1433.5 ft

BC Hydro
Figure 2  Kinbasket Reservoir Hydrograph


Study date: June 12/07

Actual Min Level (Apr 27) = 2376.4 ft

Level = 2419 ft

01Jan 01Feb 01Mar 01Apr 01May 01Jun 01Jul 01Aug 01Sep 01Oct 01Nov 01Dec

Reservoir Level (ft)

Reservoir Level (m)


Maximum Minimum Mean (1976 - 2005) Normal Min Normal Max Flood Control Level Series2
Monitoring Study No. CLBMON-36
Kinbasket and Arrow Lakes Reservoirs:
Nest Mortality of Migratory Birds due to Reservoir Operations

1.0 MONITORING PROGRAM RATIONALE

1.1 Background

Riparian habitats cover less than 1% of the landscape in western North America (Knopf et al. 1988) but support a disproportionate number of bird species (Knopf & Samson 1994; Skagen et al. 2005). It has been reported that 95% of riparian habitat in North America has been degraded or destroyed as a result of human activities (Dahl 1990; Noss et al. 1995). Loss and degradation of riparian habitat has been linked to the population declines of many migratory birds (DeSante & George 1994; Ohmart 1994).

Riparian habitats along the impounded portions of the Columbia River provide important nesting habitat for birds (Andrusiak & Simpson 1994; Boulanger et al. 2002). At Revelstoke Reach, located at the north end of the Upper Arrow Lakes Reservoir, 74 species of birds have been documented, of which 41 are known to breed in the area (Boulanger et al. 2002). Thirty-five species are thought to be affected by the operations of the Arrow Lakes Reservoir (Manning - Cooper and Associates 2003).

In the Kinbasket Reservoir, significant areas of riparian habitat occur along Canoe Reach, Columbia Reach and Bush Arm (Hawkes et al. 2007), however there is little information available with respect to bird use in the drawdown zone. Due to the operation of these reservoirs, birds that rely on the drawdown for breeding habitat are vulnerable to rising water levels during spring and early summer through inundation of breeding and foraging habitat and by flooding of active nests (Jarvis 2003). Further, the loss of breeding habitat may increase competition for breeding territories, and limit access to foraging areas. These additional pressures may reduce juvenile survival resulting in lower productivity.

During the Columbia River Water Use Planning Process (WUP), the Consultative Committee (CC) identified nest mortality of birds as a key issue. One of the concerns identified was whether the drawdown zones function as a population sink, reducing the overall productivity and viability of bird populations that breed in these habitats. To address these uncertainties, the CC proposed that a study be undertaken to (1) determine the use of riparian habitats by breeding birds in the drawdown zone, (2) determine the degree and significance of nest mortality caused by the operations of the Kinbasket and Arrow Lakes Reservoirs, (3) investigate the direct and indirect impacts of reservoir operations on the productivity and survival of birds that utilize riparian habitat within the drawdown zone , (4) inform and evaluate the effectiveness of physical works and revegetation efforts to enhance nesting success and bird productivity, and (5) assess the implementation of the soft constraints and any incremental impacts resulting from the addition of unit 5 at Revelstoke Dam. This data will also help refine the habitat models developed previously for birds nesting in the drawdown zone of Revelstoke Reach (Axys Environmental Consulting 2002).
1.2 Management Questions

This monitoring program is designed to address key management questions relating to the extent to which reservoir water levels affect the nesting success of birds breeding in the drawdown zones of the Kinbasket Reservoir and Arrow Lakes Reservoirs, and the significance of nest mortality to bird populations. The management questions to be addressed include:

a) Which bird species breed in the drawdown zones of the Kinbasket and Arrow Lakes Reservoir and where do they occur?

b) What are the seasonal patterns of habitat use by birds nesting in the drawdown zone of the Kinbasket Reservoir and Revelstoke Reach?

c) Do reservoir operations directly affect nesting success (e.g. flooding of nests)?

d) What are the factors that influence nest mortality in the drawdown zone?

e) Do reservoir operations indirectly affect nesting success by altering nesting habitat (vegetation characteristics, habitat configuration)?

f) If reservoir operations negatively affect the nesting success, what is the significance of these impacts on bird populations?

g) Do reservoir operations affect juvenile survival and recruitment?

h) Can the operations of the Kinbasket and Arrow Reservoirs be optimized to improve nesting success?

i) Provide recommendations for physical works projects and revegetation efforts to increase nesting success and juvenile survival in the Kinbasket Reservoir and Revelstoke Reach.

j) Evaluate the effectiveness of revegetation efforts and physical works projects implemented during the course of this monitoring program for improving nesting success or juvenile survival.

1.3 Management Hypothesis

The management hypotheses to be tested by this study are:

\( H_1: \) The annual and seasonal variation of water levels in Revelstoke Reach and the Kinbasket Reservoir and the implementation of soft operational constraints and potential effects of unit 5 in Arrow Lakes Reservoir do not directly affect the nesting success of migratory breeding birds.

\( H_{1A}: \) Nest mortality is no greater in the drawdown zone than above the drawdown zone.

\( H_{1B}: \) Nest mortality in the drawdown zone is not caused directly by nest inundation.

\( H_2: \) The annual and seasonal variation of water levels in Revelstoke Reach and the Kinbasket Reservoir and the implementation of soft operational constraints and potential effects of unit 5 in Arrow Lakes Reservoir do not affect juvenile survival.
H2A: Juvenile mortality is no greater in the drawdown zone than above the drawdown zone.

H3: The annual and seasonal variation of water levels in Revelstoke Reach and the Kinbasket Reservoir and the implementation of soft operational constraints and potential effects of unit 5 in Arrow Lakes Reservoir do not affect nesting or recruitment habitat required by migratory breeding birds.

H3A: Reservoir operations do not result in a reduction in the quality or availability of nesting or recruitment habitat.

H3B: Increased nest mortality, lower recruitment, and lower juvenile survival are not associated with habitat conditions (e.g. structure, vegetation composition and extent of habitat) or changes in habitat conditions within the drawdown zone?

H4: Revegetation or physical works do not increase the utilization of habitats by nesting birds in the drawdown zone.

H4A: Revegetation or physical works do not increase the species diversity or abundance of birds nesting in the drawdown.

H4B: Revegetation or physical works are not effective at reducing nest mortality in the drawdown zone.

H4C: Revegetation or physical works do not increase the survival of juvenile birds in the drawdown zone.

H4E: Revegetation or physical works do not increase the amount of bird habitat in the drawdown zone.

1.4 Key Water Use Decision Affected

The key operating decisions affected by this monitoring program are the operating regimes for the Kinbasket Reservoir and the implementation of soft constraints for the Upper Arrow Lakes Reservoir/Revelstoke Reach. For the Kinbasket Reservoir, this monitoring program will assess the impact of reservoir operations and revegetation on the nesting success of breeding birds, and evaluate whether operational changes will improve reproductive success. For Revelstoke Reach and Upper Arrow Lakes Reservoir, operational changes will be limited to soft constraints that govern daily operations such as timing, magnitude and flow rate as opposed to hard constraints that include reservoir and turbine capacities, spillway rating, licensing requirements and Columbia River Treaty obligations.

This information will help determine the magnitude and significance of nest mortality and guide the development of recommendations with respect reservoir operations and physical works required to enhance nesting success. The data will also help to evaluate the effectiveness of the works undertaken.
2.0 MONITORING PROGRAM PROPOSAL

2.1 Monitoring Objectives and Scope

The objectives of this monitoring study are to:

1) Identify important breeding habitats used by migratory birds in the drawdown zones in the Kinbasket Reservoir and Revelstoke Reach.

2) Evaluate how the operations of the Kinbasket and Arrow Lakes Reservoirs influence nest mortality.

3) Determine the effects of reservoir operations on the productivity and juvenile survival of birds breeding in the drawdown zones of the Kinbasket Reservoir and Revelstoke Reach.

4) Provide recommendations to reduce nest mortality and increase juvenile survival and productivity for birds breeding in the drawdown zones.

5) Evaluate how the operations of the Kinbasket and Arrow Lakes Reservoirs influence nesting habitat availability and quality.

6) Evaluate the effectiveness of physical works and revegetation efforts at reducing nest mortality and increasing juvenile survival and productivity for birds breeding in the drawdown zones.

This monitoring program will be implemented over a 10 year period in order to provide a long-term dataset on habitat use, nest success, survival and productivity. At years 5 and 10, results from this study and related studies will be evaluated to assess the impacts of reservoir operations, the implementation of soft constraints and the effectiveness of physical works to meet the wildlife objectives set by the CC.

2.2 Approach

During the Columbia River WUP, the CC proposed using an approach based in part on the Monitoring Avian Productivity and Survival (MAPS) program to monitor the survival and productivity of breeding birds. While the MAPS program does provide a standardized protocol for monitoring population sizes, productivity rates and survival rates of breeding birds (DeSante et al. 2007), the program does not monitor nest success or nest mortality rates. The approach presented in this monitoring program will monitor nest success and mortality directly, characterize habitats, and employs a focal species approach to monitor juvenile survival and productivity of three focal species.

This monitoring program will follow the same general approach for both Kinbasket Reservoir and Revelstoke Reach. To facilitate objectives 1 and 2, this program will focus on quantifying the use of riparian habitat types within one meter elevation bands by nesting birds and evaluate how annual and seasonal variation in water levels influence nest success. This approach will entail pre-stratifying floodplain habitats within the drawdown zone using data from the Arrow Reservoir and Kinbasket Reservoir vegetation inventories (CLBMON-33 and CLBMON-10, respectively).
To monitor nest success, fixed plots will be established in the drawdown zone and in reference habitats. Plots will be surveyed at weekly intervals throughout the breeding season (early May to late July). The nests of all bird species encountered will be documented and monitored throughout the breeding season to determine whether the eggs hatch and the nestlings fledge to calculate nest success and mortality rates (Mayfield 1961). Additional vegetation and habitat characteristics will be measured after nesting attempts have been completed to minimize disturbance impacts on reproductive success.

To determine the productivity and survival of breeding birds in the drawdown zone, the population dynamics of three focal species that occupy different habitats within the drawdown zone will be monitored. A focal species approach utilizes a subset of sensitive species to represent a broader array of species occupying habitats of interest (Lambeck 1997). This approach has been used effectively for woodland bird species (Watson et al. 2001) and is recommended for monitoring migratory birds in other parts of British Columbia (Bezener & Bishop 2005). By focusing on a subset of species, it will be possible to examine the interaction between reservoir operations, habitat characteristics, and vital rates in greater detail than would be possible than by attempting to monitor all 40 or more species that breed in the drawdown zone (Boulanger et al. 2002).

The selection of focal species (Yellow Warblers, Willow Flycatchers, and Savannah Sparrows) within Revelstoke Reach is possible since extensive breeding bird surveys have been conducted previously (Boulanger et al. 2002; Green & Quinlan 2007; Jarvis 2001). Monitoring the same species in the Kinbasket Reservoir would allow for direct comparisons to be made between the reservoirs; however, the absence of data on the diversity and abundance of birds breeding in the drawdown zone of Kinbasket Reservoir hinders the ability to make a final decision regarding the most appropriate species to select. The selection of a focal species will therefore be reassessed after the first year of the monitoring program once additional data on the diversity and abundance of bird species breeding in Canoe Reach, Columbia Reach and Bush Arm areas become available.

Monitoring productivity and survival of the three focal species will entail constant effort mist-netting and Mark-Recapture techniques. Productivity indices can be determined as the proportion of young captured by mist-netting (Peach et al. 1996). It is important to note that because capture probabilities vary between juvenile and adult birds and that capture probabilities between age classes can vary between species (Dunn & Ralph 2005; Nur & Geupel 1993), these indices cannot be regarded as absolute measures of productivity. Nevertheless, species-specific productivity indices will enable a comparison between productivity within the habitats sampled. Mark-recapture methods that account for re-sighting probabilities will be used to estimate adult and juvenile survival in relation to variation in habitat and reservoir water levels (Pradel 1996; White & Burnham 1999).
2.3 Methods

Task 1: Project Coordination

Project coordination involves the general administration and technical oversight of the program, which will include, but may not be limited to: 1) budget management, 2) program team management, 3) logistics coordination, 4) technical oversight of fieldwork, data analysis and report preparation, 5) facilitation of data transfer among other investigations associated with the Arrow Reservoir Operations Management Plan and the Kinbasket and Arrow Reservoir Revegetation Management Plan, 6) permit applications, and 7) liaison with regulatory agencies, as required.

Any necessary research permits will be obtained from the Ministry of Environment and Canadian Wildlife Service. In Year 1, Protocols will be developed outlining capture methods, handling procedures, and tagging techniques. These protocols will be submitted along with future permit requests and will be made available for review by animal care committees.

A safety plan must be developed and submitted to BC Hydro for all aspects of the study involving field work, in accordance with BC Hydro procedures and guidelines. Specific safety training may be required (e.g. first aid, small boat operation).

Task 2: Monitoring Habitat Use, Nest Success, Survival and Productivity

a) Pre-stratification of the Study Areas

Prior to the start of field surveys, habitats in the drawdown zones of Revelstoke Reach and the Kinbasket Reservoir will be stratified using data from the Arrow Reservoir and Kinbasket Reservoir vegetation inventories (CLBMON-33 and CLBMON-10, respectively). Permanent plots will then be established in representative habitats, at reference sites above the drawdown zone, and at sites where physical works and revegetation efforts are proposed. The procedures for establishing the permanent plots will follow that of Martin et al (1997), which recommend a minimum plot size of 200 x 200 m. However, the size, number and distribution of plots will be determined during the stratification process and in consultation with the revegetation and physical works programs. The aim will be to monitor a minimum of 20 nests per plot (Martin et al. 1997). Consideration will have to be given to the human development during the stratification process and site accessibility will have to be consider personnel safety and for sampling efficiency.

Pre-stratifying the study area will need to consider a sampling scheme to monitoring the effectiveness of revegetation efforts and wildlife physical works. This will need to be coordinated between CLBWORKS-1 and CLBWORKS-2: Kinbasket and Arrow Lakes Reservoir Revegetation Program, CLBWORKS-29 and 30: Feasibility and Implementation of wildlife physical works, and CLBMON-11A and B Kinbasket and Arrow Lakes Reservoirs Effectiveness Monitoring of Revegetation and Wildlife Physical Works, as well as the other wildlife and vegetation studies monitoring undertaking effectiveness monitoring. Sampling may need to incorporate treated (revegetated or site of physical works), control sites (untreated areas in the drawdown zone), and reference sites (untreated sites above the drawdown zone).
b) Nest Success

Fixed plots will be surveyed at weekly intervals throughout the breeding season from early-May to late-July. Time constrained nest surveys will be conducted to locate a sample of nests representative of songbird, waterbird, shorebird and raptor species that nest on the ground or in the shrub layer. The nests of all bird species encountered will be documented. Active nests will be monitored twice a week to determine whether the nests hatched eggs and fledged young, and to identify causes of observed nest failures. Data on clutch size, brood size and parasitism by cowbirds will be collected where possible and precautions will be taken avoid any negative influence by the observers on nesting success (Martin et al. 1997). Vegetation composition and structure will be measured and the configuration of habitat surrounding the nest site will be described, for each nesting attempt. This will be done following the breeding season to minimize disturbance on nesting birds.

Vegetation composition, structure, and cover will be measured within the study plots and where nests are located. Habitat variables will be measured at several scales (nest, 5m plots, 11.3 m plots and territory scale plots) following BBIRD protocols (Martin et al. 1997) and Luttmerding et al (1998). Habitat configuration metrics (e.g., edge/area ratios, % contiguous habitat, number and mean size of habitat patches) will be obtained by mapping the habitats using GIS within the study plots.

c) Productivity and Juvenile Survival

Based on previous bird inventories and monitoring studies in the Arrow Lakes Reservoir (Boulanger et al. 2002; Green & Quinlan 2007; Jarvis 2001), three focal species are proposed for this component of the monitoring program and include Yellow Warblers, Willow Flycatchers, and Savannah Sparrows. These species were selected because they are abundant within the study area, but are believed to be declining across B.C. (Sauer et al., 2005). Each species will act as a surrogate for species that use three major natural habitats (cottonwood/willow; willow shrub, and grass respectively). Their use of these specific habitats for nesting makes them particularly vulnerable to changes in reservoir water levels, and given the abundance and tractability of these species, there will likely be sufficient data to allow the use of sound statistical approaches to examine habitat selection, productivity and survival. Tentatively these species will also be monitored as surrogates for the broader avian community that breed in the Kinbasket Reservoir, however the final decision regarding most appropriate focal species will be determined in Year 1.

To monitor productivity and survival, mist-nets will be deployed in the pre-stratified study plots from early May to late July to capture and band juvenile Yellow Warblers, Savannah Sparrows, and Willow Flycatchers. Mist-nets will be operated following a strict protocol as the validity and accuracy of the population parameters (survival and productivity) depends on the sampling effort and the sampling timing being equal during all periods and all years. Mist-nets will be opened 30 minutes prior to sunrise and operated for exactly 6 hours. Guidelines and considerations for using the mist-nets can be found in Ralph et al (2004) and DeSante et al (2007).

All birds captured throughout the season will be identified to species and will be aged and sexed. All birds will be banded using a colour coded numbered leg band and nestlings will be colour-banded prior to fledging using if techniques described in Martin and Geupel (1993). Breeding pairs will be followed throughout the breeding
season (early-May to late-July), and their nests will be located and monitored from clutch initiation through to fledging or failure. All birds captured will be handled in compliance with provincial animal handling protocols (Resources Inventory Committee 1998).

**Task 4: Monitoring Habitat Availability and Habitat Quality**

Vegetation composition, structure, and cover will be measured within the study plots and where nests are located. Habitat variables will be measured at several scales (nest, 5m plots, 11.3 m plots and territory scale plots) following BBIRD protocols (Martin et al. 1997) and Luttmerding et al (1998). Habitat configuration metrics (e.g., edge/area ratios, % contiguous habitat, number and mean size of habitat patches) will be obtained by mapping the habitats using GIS within the study plots. Additional habitat data will be obtained by CLBMON-33 Arrow Lakes Reservoir Inventory of Vegetation Resources.

**Task: Data Analysis**

A brief summary of the data collected during each year will be provided in annual progress report. This will include a summary of sampling effort expended and an overview of the data. The intent of the data summary is to provide a synopsis of the sampling effort and results and to ensure data is QA’d on an annual basis. In Year 1, some preliminary analysis will be required to assess whether the appropriate focal species were selected to monitor bird productivity and juvenile survival. Comprehensive analysis of the data will be conducted at Years 5 and 10.

Statistical models have been developed to estimate nest success and nest mortality (Hensler & Nichols 1981; Mayfield 1961), productivity (Bart et al. 1999; Peach et al. 1996), and survival (Colbert et al. 1987; White & Burnham 1999). Analyses of habitat data collected from nest investigations and from habitat data provided under the Arrow Reservoir and Kinbasket Reservoir vegetation inventories (CLBMON-33 and CLBMON-10) projects will be used to examine habitat selection (e.g. logistic regression) for birds breeding in the drawdown zone and to assess the magnitude and significance of the reservoir operations (e.g. linear regression). Nest success will be compared between the sites where revegetation or physical works have been undertaken (treated) to untreated and control sites.

**Task 4: Reporting**

A brief progress report will be prepared annually. At Year 5 and Year 10, detailed technical reports will be prepared.

**Annual reporting:**

A progress report will be prepared each year and will include:
- A brief description of the project background.
- A brief description of the method.
- A summary of the sampling effort and preliminary results (e.g. numbers of nests located for each species by the location and fate of these nests).
- Maps of the study areas and locations of the study plots. Plot locations are to be provided as UTM coordinates in an MS Excel spreadsheet.
A digital appendix with
• A database of nest observations.
• A database of vegetation and habitat measurements associated with each study plot and nest.
• A database of Mark-Recapture data.

The progress report for year one will also include a detailed summary of the breeding biology of each focal species studied and an assessment of whether Yellow Warblers, Savannah Sparrows, Willow Flycatchers are the appropriate focal species and recommend alternative species, if necessary. The progress report for year one will also include any recommendations with respect to the study design.

As part of the Canadian Migration Monitoring Network, the capture-banding data will be submitted annually to the Canadian Wildlife Service in the appropriate format (MS Excel).

Also in year one of the study, sampling protocols will be developed describing the location of study plots in the Revelstoke Reach and Kinbasket Reservoir and describing in detail the procedures to be followed in future years.

5 Year and 10 Year reports:

A detailed technical report will be prepared in Year 5 (interim report) and at the conclusion of the study in Year 10. The interim report will allow the initial results of this study to be incorporated in plans for wildlife physical works (CLBWORKS-30) in Revelstoke Reach, which form part of the Arrow Reservoir Wildlife Management Plan. These reports shall include:

• an executive summary;
• a detailed description of the methods employed;
• a detailed analysis of the data;
• a comparison of results among years; and,
• a detailed summary of the findings as they relate to the ecological hypotheses and the key management questions.

A final digital appendix with data from all years including:
• A database of nest observations.
• A database of vegetation and habitat measurements associated with each study plot and nest.
• A database of Mark-Recapture data.

Reports will follow the standard format for WUP monitoring projects. All reports will be provided in hard-copy and as Microsoft Word and Adobe Acrobat (*.pdf) format, and all maps and figures will be provided either as embedded objects in the Word file or as separate files. The locations and associated data significant species such as species at risk will be provided to the Ministry of Environment following the Wildlife Species Inventory (WSI) standards (http://www.env.gov.bc.ca/wildlife/wsi/formats.htm).
2.4 Interpretation of Monitoring Program Results

The data collected in this monitoring program will be used to test hypotheses about how the operating regimes of the Kinbasket and Arrow Lake Reservoirs influence nest mortality, juvenile survival, and habitat (availability and quality). The results from this program will be used to address the uncertainty regarding the benefits of minor modifications to operating conditions that could enhance habitat within the drawdown zone to support breeding bird populations. The significance of any impacts of reservoir operations on these populations will be assessed by determining the extent to which water levels influence nest mortality, productivity, juvenile survival, and habitat. Detailed data on the relationship between habitat features, nest site selection, productivity and survival will inform mitigative efforts aimed at providing habitat for breeding birds in the drawdown zone and facilitate the effectiveness of revegetation and physical works in this regard.

2.5 Schedule

This program will be implemented over 10 years with field tasks undertaken in each year of study. The anticipated annual schedule for each key task is presented in Table 36-1. At Year 5, a detailed interim report will be produced to allow the initial results of this study to be incorporated into plans for wildlife physical works. A final report will be prepared in year 10.

Table 36-1. CLBMON-36 Schedule of Tasks

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<tr>
<th>Tasks</th>
<th>May</th>
<th>Jun</th>
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<td>1. Project Coordination</td>
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<td>2b. Productivity and survival</td>
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<td>3. Data analysis</td>
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<td>4. Reporting</td>
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2.6 Budget

The average annual cost over 10 years with 2% inflation is $385,843. This is higher that the cost estimated by the WUP Consultative Committee ($300,000 in 2004 dollars). This increase in budget is due to the amount of monitoring required and the geographic extent of the survey area, which includes Bush Arm, Canoe Reach, and Revelstoke Reach. Table 36-2 provides an annual budget and cost breakdown over the 10-year period.
3.0 References


